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The Factorial Structure of the Wechsler Preschool and Primary Scale of Intelligence

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THE FACTORIAL STRUCTURE OF THE WECHSLER PRESCHOOL AND PRIMARY SCALE OF INTELLIGENCE.

by

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Life

Gerald O'Keefe was born October 19, 1946 in St. Paul, Minnesota. He was graduated magna cum laude from the College of St. Thomas in St. Paul, Minnesota in January of 1968. Currently the author is working as an intern in Clinical Psychology at the Veterans Administration Hospital in Hines, Illinois.

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Chapter I

Introduction and Survey of the Literature

The purpose of the present study is to determine the factorial composition of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI). A further purpose is to determine whether this factorial composition is affected by age or sex. The study has broader developmental implications in that a comparison of the factorial structure of the WPPSI (used at ages 4-6) with the factorial structure of similar tests used at older levels may show if and how factors emerge and change with age.

Since the introduction of the Wechsler Adult Intelligence Scale and the Wechsler Intelligence Scale for Children, there has been some interest in the factorial composition of these scales. Some of the best known work in this area has been done by Jacob Cohen. In all his factor analytic studies, Cohen did oblique rotations, and the primary factors were subjected to a second order general factor analysis. Cohen's 1957 factor analysis of the WAIS standardization data revealed three major factors and two minor factors. The three major factors were similar to those identified on earlier studies of the Wechsler-Bellevue. They were:

> Factor A - Verbal Comprehension - This factor included vocabulary richness and vocabulary-symbolic manipulation ability.
>
> Factor B - Perceptual Organization - This factor included the organization of nonverbal visually perceived material against a time limit.

Factor C - Memory - (Called Freedom from Distractibility in earlier W-B and later WISC studies). This factor involved both immediate memory as well as the efficiency with which previously learned material can be called up when needed.

The two minor factors were Picture Completion Specific and Digit Symbol Specific, both of which loaded consistently on only one subtest. They had no analogues in the W-B studies.

Finally a second order factor was found and interpreted as "present general intellectual functioning" and identified as G. This factor accounted for about one-half of the total variance of the subtests.

Cohen (1959) did a comparable factor analysis of the WISC standardization data at three age levels (7-6, 10-6, and 13-6). He found five correlated factors in all three age groups. These were:

Factor A - Verbal Comprehension I - This factor seemed to reflect that aspect of verbally retained knowledge impressed by formal education; it included facts (Information), verbal categorizing (Similarities) and number manipulation (Arithmetic).

Factor B - Perceptual Organization - This factor included the nonverbal interpretation and/or organization of visually perceived materials against a time limit.

Factor C - Freedom from Distractibility - (Erroneously termed Memory in Cohen's WAIS study). - This factor included ability to remain undistracted, to attend or to concentrate.

Factor D - Verbal Comprehension II - This factor remained quasi-specific in Cohen's WAIS study. It reflected application of judgement to situations following some implicit verbal manipulation.

Factor E - This factor remained quasi-specific. It appeared in Coding, and to a limited degree, Picture Arrangement. No

psychological explanation was offered.

Cohen (1959) also found a second order factor, G. This accounted for about one-third of the total variance, less than it accounted for in the WAIS. Hence, it would appear that children exhibit a smaller degree of generality of intellectual functioning than do adults. This finding is directly contrary to the differentiation hypothesis, advanced by Garret (1946). This hypothesis states that intelligence changes in its organization as age increases from a fairly unified and general ability to a loosely organized group of abilities or factors.

The differentiation hypothesis is further weakened by a 1968 study by Silverstein. He divided the variance on the subtests of the WAIS, WISC and WPPSI into three components, variance common to the other subtests as well, variance specific to the subtest in question, and error variance. His results showed common variance to increaseswith age whereas specific variance decreases with age.

Concerning a related developmental question, the change of first order factors with age, Cohen (1959) concluded that there is more consistency than change. He also concluded that factors found in the WISC study are essentially the same as those found in the WAIS study. In addition, in evaluating the results of his WAIS study in terms of age groups, Cohen (1957b) found there was remarkable consistency in the four age groups studied (18-19, 25-34, 45-54, 60-over 75). The only exception to this consistency was found in the

eldest group in which the memory (Freedom from Distractibility) factor underwent a sharp increase in variance at the expense of the general factor. This group was also deficient in Factor E of the WAIS study, Digit Symbol Specific.

Cohen's findings concerning the stability of factors on the Wechsler scales with age are in agreement with those of Gault (1954), Balinsky (1941), Davis (1956) and Saunders (1959). However, Birren (1952) and Greene and Berkowitz (1964) have concluded that the factor structure of the Wechsler does not change with chronological age.

Osborne has done an intensive longitudinal study concerning the factorial structure of the WISC at different age levels (Osborne, 1963, 1965; Osborne, Anderson & Bradshaw, 1967; Osborne, Anderson & Hemberger, unpublished study). In these studies rotations were orthogonal and there were, of course, no second order analyses. The children were tested at preschool, first grade, and third grade levels. There are plans to test them again at fifth grade level.

Osborne, Anderson, and Bradshaw (1967) and Osborne, Anderson, and Hemberger (unpublished study) reported that five factors were required to account for a minimum of 75 percent of the variance. In the analyses at all three age levels, the first seven factors were either common or specific factors for the WISC verbal test splits while the last five factors were dominated by WISC performance variables.

In summarizing his results, Osborne noted that in general the communalities are all quite large, but this he stated is obtained at least in part, because the splits of the WISC variables (the subtest were split into two, three, or four parts for the purpose of the factor analysis) bring specific variance into the common factor space and because several specific factors are included in the rotations. Osborne noted further that the loadings for the third grade analysis show somewhat more cohesiveness in the sense that there is not so much "splintering" at that level. Most of the splintering occurred in the verbal subtests at the lower age levels.

In the preschool analysis (ages at initial testing ranged from 5-6 to 7-4 with a mean of 6-1) the first factor was a vocabulary factor. The second, factor was a Similarities factor with some small loading by I3[1]. The third factor was an Arithmetic factor with an appreciable amount of Information and V2. The fourth factor was a Comprehension factor with single splits from Information and Vocabulary. The fifth factor was fairly specific for C3, factor VI for I1, and factor VII for Df. The last five factors were dominated by performance variables. Factor VIII was a Picture Completion factor;

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1 Code -- variables are as follows: I = Information 1, 2, 3 (the Information subtest was split into three different groups); C = Comprehension 1, 2, 3; A = Arithmetic 1, 2; S = Similarities 1, 2; Df = Digit Span Forward; Db = Digit Span Backward; V = Vocabulary 1, 2, 3, 4; PC = Picture Completion 1, 2, 3; PA = Picture Arrangement 1, 2; BD = Block Design 1, 2; OA = Object Assembly 1, 2.

factor IX a Picture Arrangement factor; factor X a Block Design factor and factor XI an Object Assembly factor. The twelfth factor had a major loading for Coding, with loadings as well for PC1 and I3.

For the first grade level analysis, the first factor was a Vocabulary factor, with C1 and C2 also loading some; factor I1 was a Similarities factor; factor III an Information factor; factor IV a Comprehension factor; factor V had a major loading for A2, with loadings on I1 I2, V4, and A1 as well. Factor VI which had major loadings for A1 Df and a slight loading for OA1, appeared to Osborne to be something of a number-memory factor. Factor VII was specific for Df. Factor VIII was a Picture Arrangement factor with additional loadings for OA2, OA1 Df and V1. Factor IX was a Block Design factor with some loading for Object Assembly. Factor X was a Picture Completion factor. PC3 is a singlet for Factor XI. Factor XII was very specific for Coding.

For the third grade analysis the first factor was a fairly general verbal factor with a very major loading for Vocabulary, Similarities, and Information. The second factor was Arithmetic. Factor III loaded principally for Df with loadings for I1 and I2. Factor IV was specific for Df, factor V for C1, factor VI for C2, and factor VII for C3. Factor VIII was a Picture Completion factor; factor IX a Picture Arrangement factor; factor X a Block Design factor and factor XI was dominated by Coding and OA1. Factor XIII was an Object Assembly factor.

Osborne (1967) canonically correlated the three sets of factor scores. Osborne stated that the first canonial correlation may be taken as a reliability index for correlations of the scales over time. These reliabilities are .87 from preschool to first grade, .85 from preschool to third grade and .87 from first grade to third grade. In commenting on the other correlations Osborne merely noted the complexity of the relationships. There were four significant dimensions in the relationship between preschool and first grade levels, three between first and third grade levels, and two between preschool and third grade levels.

Osborne and his associates have also investigated the effects of sex and race in their longitudinal study. Generally speaking, they have found eight continious WISC variables from preschool through grade three (Osborne and Lindsey, 1967, unpublished study; Lindsey, 1966). These same eight factors still emerged when the samples were divided by race and sex.

In analyzing the data for third grade males and third grade females, Osborne and Lindsey (unpublished study) extracted six factors for the male subjects and eight factors for the female subjects. For each male factor identified, a highly similar female factor also emerged. The females required two factors to account for their performance on factor A (verbal) for the male data. The other additional factor simply does not appear in the male data. The sex difference noted here appears to be small and Osborne and Lindsey concluded that the similarities are more impressive than the differences.

Osborne (1964, 1966) and Osborne and Lindsey (1967) have published separate data for white and Negro children. Although they did not directly compare the two samples, Lindsey (1966) concluded that racial differences were small. The other studies suggest the same conclusion.

Meyers and Dingman (1960) have reviewed the literature on the structure of intelligence at preschool ages and argue that there are rather specific abilities at the preschool levels. Meyers and Dingman's 1960 review found only five studies, all American, which dealt with structure of abilities at the preschool level.

Richards and Nelson (1939) analyzed the inter-item tetrachoric r's of the Gessel items. At 6, 12, and 18 months, two factors, one labelled "alertness" and the other "motor" were found.

McNemar (1942) factor analyzed the 1937 Stanford-Binet and included analyses designed to disclose whether the item selection was done carefully enough to avoid group factors. McNemar's results show that the 1937 Binet did not avoid this pitfall. Hofstaetter (1954) analyzed a matrix of interage test correlations. The results showed a "sensorimotor" alertness with best loadings in the first two years, "persistence" from two to four, and intelligence from three years on.

Meyers and Dingman (1960) point out that the above mentioned three studies were analyses of already existing data. Only in Kelly and Thurstone's studies were data obtained by the authors for the specific purpose of factor

Kelly (1928) reported on factors at the kindergarden, third grade, and seventh grade levels. For the kindergarden group, Kelly reported six factors: maturity-heterogenity, verbal, memory, spatial no. 1, spatial no. 2 and control of meaningless content. The first factor, maturity-heterogenity loaded heavily for all tests used, but Kelly did not call it G, believing the evidence for G was really due to insufficiently controlled variability in sex, age, and background of the subjects, and hence named his own first factor maturity-heterogenity. Meyer and Dingman (1960) added that what Kelly called "verbal" should be called "memory span" or "immediate memory" because the items did not require semantic interpretation, only serial recital.

The second "analysis for factors' sake" at preschool levels reviewed by Meyers and Dingman is that of Thurstone and Thurstone (1953). This was the research leading to the Primary Mental Abilities (PMA) tests, which have a level for ages five through seven. The 5-7 PMA has the following areas: motor, perceptual speed, verbal, spatial, and quantitative. The Thurstones' work showed less evidence of factor clarity at ages 5-7 compared with higher age levels. Meyers and Dingman (1960, p. 520) concluded their literature review by saying:

> The PMA's can not be considered replications of specific Kelly factors but the two reports do reinforce the conviction that factors can be found. Note that Kelly had a first factor loading called maturity-heterogenity and the Thurstones found considerable interfactor correlation. To

label either result the consequence of G is as unwarranted at this time as to conclude the cause is differential testability or variance due to testing conditions. The McNemar report had little common factor variance beyond the first loading, but in this instance "purity" was built into the test material by preliminary steps. The general conclusion, therefore, is that factors will emerge once appropriate test materials are made available.

Meyers and Dingman (1960) also presented seven hypothesized domains of factors at the preschool level. Basing their theorizing on an S-O-R viewpoint, they stated that there are three domains whose existence ought to be fairly certain: the psychomotor, the perceptual, and the psycholinguistic. Dingman and Meyers argued that the psychomotor domain splits into whole body actions and hand-eye actions, perception splits into auditory and visual perception, and that the psycholinguistic domain splits on the receptive-expressive dimensions. Hence, the three domains become six and the addition of thinking makes a total of seven.

Dingman and Meyers have given examples of early behaviors (from 1 to 30 months) that belong to each domain, as well as two to six hypothesized factors in each domain for the four to six year age level. They also have given an age for the emergence of each factor. Dingman and Meyers hypothesized factors and the age of emergence are shown in Table 1.

Concerning the issue of how various abilities develop, Dingman and Meyers stated the issue of whether abilities emerge via differentiation or via consolidation enters. They stated, however, that answers to this and related questions cannot really be answered until we have the instrumentation capable of detecting what exists.

TABLE 1

Factors Hypothesized in Seven Domain and Age of Emergence
(from Meyers and Dingman, 1960)

Domain	Factor	Age of Emergence
Psychomotor-Whole body	1.1 Postural Balance	1 1/2 years
	1.2 Dynamic Balance	1 1/2 years
	1.3 Impulsion	2 1/2 years
	1.4 Coordination	2 1/2 years
	1.5 Flexibility	3 years
	1.6 Strength	3 years
Psychomotor-Hand-Eye	2.1 Static Precision	3 years
	2.2 Dynamic Precision	3 years
	2.3 Reaction Time	3 years
	2.4 Dexterity	3 years
	2.5 Speed	4 years
Visual Perception	3.1 Perceptual Speed	1 1/2 years
	3.2 Space	3 years
Auditory Perception	4.1 Auditory Discrimination	1 1/2 years
	4.2 Auditory Localization	1 1/2 years
Receptive Psycho-linguistics	5.1 Auding	1 year
	5.2 Verbal Comprehension	5 years
Expressive Psycho-linguistics	6.1 Articulation	1 1/2 years
	6.2 Semantic Fluency	2 years
	6.3 Symbolic Fluency	3 years
Mental (thinking and memory)	7.1 Memory Span	2 1/2 years
	7.2 Abstracting	3 years
	7.3 Reproduction of Visual Models	3 years

Bayley (1953) discussed this problem and takes a more definite stand. Bayley views intelligence as a "dynamic succession of developing functions with the more advanced and complex function in the hierarchy depending on the prior maturing of earlier areas." Bayley hypothesized that a changing organization of factors is in process and this partially accounts for the fact that the scores of mental growth in individual children exhibit gradual shifts in relative status. Bayley feels that something akin to G or a high first order factor appears soon after the second or third year. The correlation of tests at this age become positive with later tests scores. After five or six years, Bayley says, it is possible to place children into the broad categories of normal, defective, and bright.

Bayley's conceptualizations are not unlike those of Piaget. Piaget (in Flavell, 1963) views intelligence as a special form of adaptation. To cope with the environment, the organism is continually reorganizing the mind. The adaptive interaction between the organism and the environment involves two complementary processes which correspond to inner and outer adaptations. These Piaget terms assimilation and accommodation. Assimilation occurs whenever the organism utilizes something from the environment and incorporates it. Accommodation operates as the variations in environmental circumstances demand coping which modify existing schemata. Through assimilation and accommodation, the reflexive schemata present at birth are slowly transformed into the "logical" organizations that are adult intelligence.

This transformation is composed of three periods, each of which is composed of several phases. The preschool child (4-6 years) is in the intuitive phase of the preconceptual period. This is a phase of increasing conceptualization. Piaget views this conceptualization as occurring central neural processes become more and more autonomous with repetitions of various kinds of overt actions. Three fundamental "operations," classes, relations, and numbers develop as the internalization of overt activities. Classifying comes from the act of grouping things together according to some perceived similarity; assymetrical relations derive from the act of comparing and ordering objects in some aspects in which they are perceived as different. Numbers arise from the combining of classifying and ordering.

Some Conclusions

It is difficult to draw many conclusions from the literature reviewed. This is because of several interlocking reasons. First, it is only possible to get out of a factor analysis what is put into it. A factor analysis is done on a particular test or tests. The only factors found will be factors that load for that test. Hence it is necessary to define intelligence in concrete, operational terms, i.e., in terms of a particular test or tests. Results are, therefore, specific to particular tests, and it is difficult to generalize about intelligence in a more abstract sense. Thus, for example, it is difficult to tie any of the factor analytic work to the work done by Piaget. I t is even difficult to see any

emergent generalizations from the work done on the Wechsler scales and the work done on other tests.

There are, however, some conclusions that seem warranted. There does seem to be some evidence for Bayley's contention that a high first order factor, often referred to as G, appears at least by the third or fourth year. It would also appear that this factor accounts for more and more variance as the child grows older. The amount of variance is stable through most of adulthood. After age sixty, however, less variance is accounted for by G.

However, even this conclusion is rather tenuous and dependent upon the type of analysis done. G has emerged as a second order factor, not a first order factor. Studies that do not employ a second order analysis do not discuss G. It is also worth noting that oblique rotations and a subsequent second order analysis is a somewhat questionable technique. Current thinking in the area of factor analysis favors an orthogonal solution (Nunnally, 1967).

It also appears safe to conclude that the factor structure of the WISC and the WAIS contain three principal factors; a verbal factor, a perceptual factor, and a memory or freedom from distractibility factor. This generalization is not as true of the WISC at the lower age levels (specifically first grade and below). At the lower age levels there is more "splintering." This fact combined with the above mentioned comments on G would seem to indicate a trend of specific to more general factors as age increases.

In the current study rotations are orthogonal and in this way, the present

study is similar to Osborne's work. However, the subtests were not split into parts as Osborne has done, so in this way the present study is similar to Cohen's work although no second order analysis was done.

The principal difference from both Cohen and Osborne is, of course, the test used and the age of the subjects. Cohen's studies were on the WISC and the WAIS and Osborne's work has been with the WISC. The youngest age groups worked with were six-year olds (Osborne) and seven-year olds (Cohen, 1959). The age range in the present study is from 4-5 to 6-4.

Chapter II

Method

Subjects

The subjects were 100 white, middle class children. There were 50 males and 50 females. There were four children, two of each sex, in each of 25 age brackets. There was an age bracket for each month from 4-5 to 6-4. Initial testing for each child was within 15 days of the day he would be the exact age of the age bracket he was assigned to. The mean Stanford Binet IQ for all Ss was 112 with a standard deviation of 15.8. The mean WPPSI full scale IQ was 106 with a standard deviation of 14.1. The Ss were presumed normal volunteers, whose parents responded either to a letter sent from several Catholic grade schools or to a personal request of one of the Es.

Procedure

There were four male examiners for the intelligence tests; each examiner tested 25 children for two sessions. Each child was tested by the same examiner for both sessions. Three tests were administered: the Stanford-Binet Intelligence Scale, Form L-M (S-B), the WPPSI, and the Matching Familar Figures (MFF) (Kagan, Moss, and Sigel, 1963). In the first session, 50 children were given the S-B, and the other fifty were given the WPPSI. In the second session each child was given either the Binet or the WPPSI, whichever one he was not given in the first session. One quarter of the children were given the MFF at the start of the first session before the

intelligence test, one quarter at the end of the first session after the intelligence test, one quarter at the beginning of the second session before the intelligence test, and one quarter at the end of the second session after the intelligence test. This counterbalancing was done across examiners, i.e. each examiner followed one of the six possible arrangements for four children with the only exception being each examiner's 25th child for which a random order was used.

The MFF was used in conjunction with another study, and the data is not included here.

Chapter III

Results

Four correlations matrices were factor analyzed. The first matrix is based on the data gathered in the present study. This group of subjects will be known as the Loyola group. There are 11 variables in this first matrix, the ten subtests of the WPPSI, and Stanford-Binet IQ. Correlation coefficients were computed by the Pearson product-moment method. The correlation matrix along with the means and standard deviations for each variable are shown in Table 2.

The other three correlation matrices are based on the standardization data and are taken from the manual (Wechsler, 1967). The second correlation matrix is based on the 100 children of each sex in the standardization sample who were tested within six weeks of their fourth birthday. They will be known as the four-year-old group. The third correlation matrix is based on the 100 children of each sex in the standardization sample who were tested within six weeks of age 6 years and 6 months. They will be known as the 6 1/2-year-old group. The fourth correlation matrix is composed of the average correlations of the WPPSI subtests for the 6 age groups, from age 4 to age 6 1/2, in the standardization sample. Each age group was composed of 100 males and 100 females. The standardization sample was composed to be representative of the United States population in terms of geographic region,

Table 2

Correlational Matrix for Loyola Group

Variable	I	V	A	S	C	AH	PC	M	GD	BD	SB
Vocabulary	.58										
Arithmetic	.61	.50									
Similarities	.55	.49	.50								
Comprehension	.45	.57	.38	.54							
Animal House	.26	.29	.41	.31	.41						
Picture Comple	.35	.26	.49	.34	.28	.31					
Mazes	.24	.24	.44	.34	.35	.36	.53				
Geometric Design	.22	.26	.36	.27	.20	.26	.22	.47			
Block Design	.34	.31	.55	.29	.22	.38	.44	.55	.51		
Stanford Binet	.72	.62	.68	.74	.55	.43	.46	.45	.41	.46	
Mean	10.7	10.2	11.0	10.4	10.7	10.6	11.5	10.8	10.7	11.4	112.4
SD	3.0	3.3	2.8	3.2	2.9	3.1	3.0	3.0	3.0	2.7	15.8

urban vs. rural residence, race, and father's occupations. This group will be known as the total group. The correlation matrices as well as means and standard deviations for each variable for each of these groups are given in Appendix A.

Each of the four correlation matrices was factored by the principal components method with the highest value in the row placed in the principal diagonal. Eigenvalues were calculated by a modified Jacobian method which closely parallels the routine given by Greenstadt (1959). A varimax rotation subroutine was used (Kaiser, 1958). The program used was MESAI (Library No. NUCC016, Vogelback Computing Center, Northwestern University).

Table 3 shows the rotated factor matrix for the total group and the percentage of variance accounted for by each factor. The unrotated factor matrix is given in Appendix B. For the total group it can be seen that the first factor is a fairly strong verbal factor. All of the verbal subtests load on it equally with the exception of Arithmetic which loads on it somewhat less. Picture Completion is the only performance subtest that loads noticeably on this factor. Factor II is a performance factor. All the performance subtests load on it although the loading for Animal House is more moderate. Arithmetic also loads on this factor and there is a minor loading for Information. Factor III is specific for Animal House. Factor IV is specific for Arithmetic. Factor V is merely a residual and no interpretation is given.

Table 3

Factor Loadings for Total Group

Factor No.	I	II	III	IV	V
Variable					
Information	.67	.33	-.20	.14	-.10
Vocabulary	.67	.29	-.14	.01	-.22
Arithmetic	.50	.45	-.21	.32	.00
Similarities	.68	.21	-.10	.02	.18
Comprehension	.71	.27	-.10	.06	-.01
Animal House	.26	.42	-.44	.05	-.02
Picture Comple	.38	.53	-.13	-.08	-.13
Mazes	.20	.65	.00	-.09	-.04
Geometric Design	.22	.61	-.24	.11	.02
Block Design	.30	.62	-.09	.16	.03
Percentage of Variance	47.32	40.33	7.67	3.33	2.11

Table 4 shows the factor matrix for the Loyola Group and the percentage of variance accounted for by each factor. The unrotated factor matrix is given in Appendix B. The results of the Loyola Group are similar to those of the total group. Instead of one verbal factor, there are two, Factors I and IV. All of the verbal subtests and the S-B load on Factor I, which accounts for most of the verbal subtest variance. Picture Completion and Block Design have small loadings on this factor. Of the verbal subtests, Vocabulary has the highest loading and Comprehension the lowest. Comprehension loads heavily on Factor IV, which also has loadings for Vocabulary, Similarities, Animal House, and the S-B. There were also two performance factors for the Loyola Group. Factor II has a heavy loading for Picture Completion with additional loadings for Arithmetic, the S-B, and all the other performance subtests with the exception of Geometric Design. Geometric Design loads heavily on Factor III, which also has loadings for Mazes, Block Design, Arithmetic and the S-B. Factor V is specific for Similarities.

Table 5 shows the rotated factor matrix for the 6 1/2 group and the percentage of variance accounted for by each factor. The unrotated factor matrix is given in Appendix B. The results for the 6 1/2-year-old group are also similar to those of the total group. The first factor is a strong verbal factor which has approximately equal loadings for all the verbal subtests, again with the exception of Arithmetic which loads more moderately. Of the performance subtests, Block Design has the heaviest loading on this factor .

Table 4

Factor Loadings for Loyola Group

Factor No.	I	II	III	IV	V
Variable					
Information	.82	-.20	.09	.07	.00
Vocabulary	.66	-.04	.14	.35	-.16
Arithmetic	.59	-.46	.31	.06	-.03
Similarities	.61	-.20	.17	.40	.29
Comprehension	.44	-.14	.07	.62	-.13
Animal House	.17	-.34	.27	.38	-.12
Picture Compl	.24	-.67	.15	.12	-.07
Mazes	.10	-.52	.48	.25	-.11
Geometric Des	.16	-.12	.69	.10	-.06
Block Design	.23	-.44	.57	.04	-.14
Stanford-Binet	.71	-.30	.32	.30	.14
Percentage of Variance	40.07	21.79	20.94	15.18	3.36

Table 5

Factor Loadings for 6 1/2 Year Old Group

Factor No.	I	II	III	IV	V
Variable					
Information	.70	.25	-.25	-.01	.17
Vocabulary	.64	.26	-.13	.29	.10
Arithmetic	.46	.39	-.41	.05	.31
Similarities	.72	.18	-.24	-.05	-.01
Comprehension	.73	.19	-.13	.09	-.01
Animal House	.22	.14	-.59	.05	.03
Picture Comple	.28	.58	-.18	-.02	-.04
Mazes	.11	.49	-.30	.37	.01
Geometric Design	.16	.41	-.50	.11	.05
Block Design	.30	.61	-.20	.13	.21
Percentage of Variance	45.23	27.75	20.39	5.10	3.47

Factor II is a performance factor that has loadings for Arithmetic and all the performance subtests except Animal House. Animal House loads heaviest on a second performance factor, Factor III. Arithmetic, Mazes and Geometric Design also load on Factor III. Factor IV is specific for Mazes. Factor V is specific for Arithmetic.

Table 6 shows the rotated factor matrix for the 4-year-old group and the percentage of variance accounted for by each factor. The unrotated factor matrix is given in Appendix B. The results for the 4-year-old group are similar to the results for the other three groups. Factor I is a strong verbal factor with equally heavy loadings on all of the verbal subtests, again with the exception of Arithmetic where the loading is smaller. Picture Completion and Animal House also load moderately on this factor. Factor II is the principle performance factor. It has loadings for all of the performance subtests, except Animal House, although it does not load strongly on Block Design. Block Design loads heavily on Factor III, which also had loadings for Arithmetic and Picture Completion. Factor IV is specific for Animal House. Factor V is specific for Arithmetic.

Looking at all the analyses together, it can be seen that there is a fairly strong verbal factor that emerges consistently. It is always the first factor and accounts for 40 to 50 per cent of the variance. All of the verbal subtests load on it about equally except Arithmetic where the loading is more moderate. Picture Completion also loads moderately in this factor. The

Table 6

Factor Loadings for 4 Year Old Group

Factor No.	I	II	III	IV	V
Variable					
Information	.69	.27	.15	.22	-.05
Vocabulary	.64	.25	.19	.15	.09
Arithmetic	.43	.35	.39	.06	-.28
Similarities	.64	.05	.28	.27	-.12
Comprehension	.72	.25	.14	.12	-.06
Animal House	.35	.23	.13	.51	.00
Picture Comple	.45	.40	.33	.10	.16
Mazes	.16	.65	.30	.09	.05
Geometric Design	.24	.66	.12	.19	-.11
Block Design	.22	.32	.55	.14	-.01
Percentage of Varience	45.97	27.87	15.76	9.25	2.72

Loyola Group is the only group that displays a second general verbal factor. Table 7 summarizes the data for the verbal factor showing the major factor loadings and the percentage of variance accounted for by the verbal factor for all four groups.

Second, there is a general performance factor that accounts for the second largest amount of the variance in all four analyses. This factor is generally comprised of the performance subtests and Arithmetic loads on this factor, and Information also has a moderate loading. For the Loyola group, Geometric Design did not load on Factor II. There is a second performance factor, Factor III, which shows moderate loadings for Arithmetic and Geometric Design, Mazes, and Block Design. Factor III for the Loyola group appears to be a visual performance factor. Factor II for the 6 1/2 year old group is similar to that found in the total group, except there is no loading for Animal House. The same is true for the 4 year old group. There is a second performance factor for this group. Block Design loaded heavily on this factor, and Arithmetic, Picture Completion, and Mazes have minor loadings. Table 8 summarizes the data for the performance factor showing the major factor loadings and the percentage of variance accounted for by the performance factor.

Hence it appears that there are two subtests that do not consistently load on one of the two main factors. These are Arithmetic and Animal House. The verbal factor consistently loads lowest for Arithmetic of all the verbal

Table 7

Factor Loadings for Principal Variables for Verbal Factor

	TOTAL GROUP		LOYOLA GROUP		6 1/2 YEAR OLD		4 YEAR OLD	
Principal Variables and Factor Loadings	Compreh.	.71	Inform.	.82	Compreh.	.73	Compreh.	.72
	Similar.	.68	S-B	.71	Similar.	.72	Inform.	.69
	Inform.	.67	Vocabul.	.66	Inform.	.70	Vocabul.	.64
	Vocabul.	.67	Similar.	.61	Vocabul.	.64	Similar.	.64
	Arithme.	.50	Arithme.	.59	Arithme.	.46	Pic. Com.	.45
	Pic. Com.	.38	Compreh.	.44	Blk. Des.	.30	Arithme.	.43
	Blk. Des.	.30					A House	.35
Percentage of Variance Accounted For	47.32		40.07		45.23		45.97	

Table 8

Factor Loadings for Principal Variables for Performance Factor

	TOTAL GROUP		LOYOLA GROUP		6 1/2 YEAR OLD		4 YEAR OLD	
Principal Variables And Factor Loadings	Mazes	.65	Pic. Com.	.67	Blk. Des.	.61	Geo. Des.	.66
	Blk. Des.	.62	Mazes	.52	Pic. Com.	.58	Mazes	.65
	Geo. Des.	.61	Arithme.	.46	Mazes	.49	Pic. Com.	.40
	Pic. Com.	.53	Blk. Des.	.44	Geo. Des.	.41	Arithme.	.35
	Arithme.	.45	A. House	.34	Arithme.	.39	Blk. Des.	.32
	A House	.42	S-B	.30				
	Inform.	.33						
Percentage Of Variance Accounted For	40.53		21.79		27.75		27.87	

subtests, and the performance factor consistently loads moderately for Arithmetic. There is a specific factor for Arithmetic in all but the Loyola group analysis. Factor IV in the total group analysis and factor V in the 4 year old and 6 1/2 year old analyses are specific for Arithmetic.

Neither the verbal nor performance factors has consistent loadings for Animal House. The performance factor in the total group analysis has a loading for Animal House, but the loading is smaller than the loadings for the other performance subtests, and there is a specific Animal House factor in this group. In the Loyola group, Animal House has moderate loadings on the second verbal factor and the second performance factor. In the 6 1/2 year-old group, Animal House does not load on the principal performance factor, Factor II. There is another performance factor which Animal House dominates. In the 4 year old group, there is a specific Animal House factor. The verbal factor also has a moderate loading for Animal House in this group.

Chapter 4

Discussion

The findings of the current study appear to be fairly consistent with Cohen's (1957a, 1957b, 1959) results on his factor analysis of the WISC and the WAIS standardization samples, indicating that even at this age level (4-6 1/2) the factorial structure of the Wechsler scales is fairly well established. Cohen reported three principal factors. The first he called Verbal Comprehension. This factor is highly similar to the verbal factor found in the present study. Like the Cohen factor, this factor reflects that aspect of verbally retained knowledge impressed by formal education. Cohen's second factor, Perceptual Organization, which includes the nonverbal interpretation and/or organization of visually perceived materials against a time limit, is similar to the performance factor in the present study. Cohen's third factor, Freedom from Distractibility, was not clearly found here, but a specific Arithmetic factor was found in three analyses, a somewhat analogous finding. I n the Cohen studies, the Freedom from Distractibility factor loaded for Arithmetic and Digit Span. There is no analogous Digit Span in the WPPSI and this may explain why there was no Freedom from Distractibility factor found in the present study.

In his study of the WAIS Cohen (1957a) found a specific factor for Digit Symbol, and in his WISC study Cohen (1959) found a specific factor for Coding. The WPPSI analogue for these two subtests is Animal House, for which there

was a specific factor in the present study.

The fact that the results closely parallel those of Cohen while differing from those of Osborne is most likely a reflection of the method used. Osborne's technique of splitting up the subtests leads to many more specific factors and leads Osborne to conclude that a general verbal factor does not emerge until third grade. The fact that the present study found much more generality of factor structure at the lower age level than Osborne did at a higher age level, is apparently due to the fact that the present study did not split up the subtests into parts for the factor analysis.

There is another parallel finding to Cohen's (1959) WISC study in the Loyola group results. The second verbal factor that emerged in the Loyola group analysis is similar to the second verbal factor in Cohen's (1959) WISC study. This factor, like Cohen's reflects the application of judgment to situations following an implicit verbal manipulation. It is not clear why this factor was found in the Loyola group and not in any of the other analyses. The other three analyses are based on Wechsler's standardization data, as was Cohen's analysis of the WISC, and the Loyola group sample is thus most different of any of the four from Cohen's sample. Hence the difference in results between between the Loyola group and the other three groups, and the Loyola group's similarity to Cohen's results is not due to differences in sampling.

There appear to be no differences in factor structure with age. The

results for the 4 year old group did not differ from those of the 6 1/2 year old group and both were similar to those of the total group. However, it should be realized that the 200 subjects who made up the 4-year-old group and the 200 subjects that made up the 6 1/2-year-old group were also members of the 1200 subjects of the total group. This fact, of course, increased the similarity of the results between the two smaller groups and the total group.

The results of the Loyola group analysis indicate that the S-B at this age level is primarily a measure of formally acquired verbal skills. It loaded heavily on Factor I which reflects formally acquired verbal skills.

Chapter V

Summary

Four correlation matrices of the 10 WPPSI subtests were factor analyzed by the principal components method. The first matrix was based on 50 children of each sex who ranged in age from 4-5 to 6-4. This matrix included Stanford-Binet IQ as an additional variable. The other three matrices were based on the 4-year-old and 6 1/2-year-old groups in the standardization sample. The fourth matrix was based on the entire standardization sample. It was concluded that the factorial structure of the WPPSI is composed principally of a verbal factor and a performance factor. Two subtests, Arithmetic and Animal House appears to be specific factors. The verbal factor had strong loadings for Information, Vocabulary, Similarities, and Comprehension, and moderate loading for Arithmetic. The performance factor loads for Mazes, Geometric Design, Block Design, and Picture Completion. There were no sex or age differences. The results are highly similar to those of some factor analytic studies of the WAIS and WISC.

Appendix A

Correlational Matrix for Total Group
(from Wechsler, 1967)

	I	V	A	S	C	AH	PC	M	GD
Vocabulary	.60								
Arithmetic	.58	.49							
Similarities	.53	.49	.46						
Comprehension	.60	.57	.51	.55					
Animal House	.41	.36	.42	.31	.34				
Picture Comple	.47	.45	.42	.36	.42	.38			
Mazes	.37	.35	.41	.28	.33	.36	.44		
Geometric Design	.40	.35	.47	.30	36	.43	.42	.48	
Block Design	.43	.38	.50	.35	.39	.38	.45	.46	.48

Correlation Matrix for 6 1/2 Year Old Group (from Wechsler, 1967)

	I	V	A	S	C	AH	PC	M	GD	BD
Vocabulary	.59									
Arithmetic	.59	.50								
Similarities	.60	.51	.49							
Comprehension	.58	.56	.45	.60						
Animal House	.34	.27	.41	.33	.25					
Picture Comple	.40	.36	.40	.35	.32	.25				
Mazes	.25	.37	.38	.23	.24	.30	.36			
Geometric Design	.34	.30	.47	.28	.30	.39	.37	.41		
Block Design	.43	.42	.55	.37	.39	.27	.46	.46	.41	
Mean	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
S.D.	3.0	3.1	3.0	3.1	3.1	3.0	3.0	3.1	3.0	3.0

Correlation Matrix for 4 Year Old Group (from Wechsler, 1967)

	I	V	A	S	C	AH	PC	M	GD	BD
Vocabulary	.56									
Arithmetic	.49	.41								
Similarities	.58	.48	.46							
Comprehension	.61	.57	.48	.57						
Animal House	.44	.38	.30	.42	.39					
Picture Comple	.51	.45	.42	.42	.47	.34				
Mazes	.35	.31	.39	.25	.34	.28	.47			
Geometric Design	.41	.38	.44	.27	.38	.36	.40	.53		
Block Design	.33	.38	.46	.35	.32	.30	.42	.43	.35	
Mean	9.9	9.9	9.8	9.9	9.9	9.9	10.0	10.0	9.9	9.9
S.D.	3.1	3.0	3.1	3.1	3.1	3.0	2.9	3.1	3.1	3.1

Appendix B

Unrotated Factor Matrix for Total Group

Factor No. / Variable	I	II	III	IV	V
Information	.76	-.20	.01	-.06	-.06
Vocabulary	.71	-.25	-.16	-.09	-.08
Arithmetic	.73	.01	.20	.02	-.13
Similarities	.64	-.31	.08	.11	.17
Comprehension	.71	-.29	-.01	.05	.02
Animal House	.57	.17	.09	-.24	.10
Picture Comple	.64	.12	-.20	-.01	.03
Mazes	.59	.33	-.12	.09	.02
Geometric Design	.62	.32	.06	-.01	.02
Block Design	.65	.24	.04	.13	-.04

Unrotated Factor Matrix for Loyola Group

Variable	I	II	III	IV	V
Information	.72	.03	-.33	-.30	-.06
Vocabulary	.67	.18	-.32	.04	-.17
Arithmetic	.78	-.06	.06	-.24	.03
Similarities	.72	-.07	-.30	.08	.23
Comprehension	.63	.00	.26	.36	-.18
Animal House	.52	-.13	.11	.24	.12
Picture Comple	.58	-.34	.26	-.08	-.13
Mazes	.61	-.07	.44	.14	.04
Geometric Design	.50	.36	.37	.04	.15
Block Design	.62	.10	.43	-.09	-.02
Stanford-Binet	.87	.01	-.17	-.06	.13

Unrotated Factor Matrix for 6 1/2 Year Old Group

Variable	Factor No. I	II	III	IV	V
Information	.75	.07	-.05	-.26	.07
Vocabulary	.71	-.20	.14	-.19	.04
Arithmetic	.75	.08	-.09	.08	.20
Similarities	.69	.05	-.08	-.33	-.10
Comprehension	.68	-.06	.05	-.35	-.08
Animal House	.49	-.05	-.37	.17	-.04
Picture Comple	.58	.19	.17	.18	-.16
Mazes	.52	-.20	.12	.38	-.04
Geometric Design	.57	.00	-.16	.34	-.05
Block Design	.67	.09	.21	.23	.10

Unrotated Factor Matrix for 4 Year Old Group

Factor No.	I	II	III	IV	V
Variable					
Information	.76	-.22	-.08	-.06	-.02
Vocabulary	.69	-.17	-.04	-.09	.12
Arithmetic	.67	.08	.21	-.02	-.21
Similarities	.68	-.32	.11	.11	-.04
Comprehension	.73	-.24	-.04	-.15	-.04
Animal House	.56	-.08	-.20	.30	.02
Picture Comple	.67	.10	.03	-.07	.19
Mazes	.58	.45	-.05	-.04	.05
Geometric Design	.61	.34	-.21	-.02	-.14
Block Design	.57	.23	.26	.14	.08

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APPROVAL SHEET

The thesis submitted by Mr. Gerald O'Keefe has been read and approved by members of the Department of Psychology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts.

5-30-70
Date

Signature of Advisor